REPORT DOCUMENTATION PAGE

Form Approved
OMB NO. 0704-0188

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE 20 Dec 00	3. REPORT TYPE AND DATES COVERED FINAL 01 Aug 96 - 30 Apr 00

4. TITLE AND SUBTITLE Visual Communications: The Next Generation - Compression, Access, and Delivery of Visual Information	5. FUNDING NUMBERS DAAH04-96-1-0342
6. AUTHOR(S) Kannan Ramchandran	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of Illinois - Urbana @ Champaign	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U. S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211	10. SPONSORING / MONITORING AGENCY REPORT NUMBER ARO 35604.12-CI-YIP

11. SUPPLEMENTARY NOTES

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12 a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited.	12 b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

This ARO-YIP grant resulted in the creation of novel paradigms for the representation, compression, and delivery over noisy channels and hetergeneous networks of images and video. Several publications resulted from this work and formed the core of two M.S. and one Ph.D. theses. The projects included hybrid analog/digital framework for source-channel coding of images, region-based video coding using mathematical morphology, and multiresolutional motion estimation and video coding on wavelets.

14. SUBJECT TERMS	15. NUMBER OF PAGES
	16. PRICE CODE

17. SECURITY CLASSIFICATION OR REPORT **UNCLASSIFIED**	18. SECURITY CLASSIFICATION ON THIS PAGE **UNCLASSIFIED**	19. SECURITY CLASSIFICATION OF ABSTRACT **UNCLASSIFIED**	20. LIMITATION OF ABSTRACT **UL**

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DAAH04-96-1-0342

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>TITLE: Visual Communications: The Next Generation - Compression,
> Access, and Delivery of Visual Information

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> SUMMARY
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>This ARO-YIP grant resulted in the creation of novel paradigms for the
>representation, compression, and delivery over noisy channels and
>heterogeneous networks of images and video. Several publications resulted
>from this week, and this work formed the core of two M.S. and one Ph.D.
>theses. A brief summary of the projects follows in the following
>sections of this final report.

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>1) Hybrid analog/digital framework for Source-Channel Coding of images

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> The aim of this project was to consider the problem of image
> transmission over wireless channels using joint source-channel
> coding. Inspired by both information-theoretic principles and
> realistic wavelet-based image models, we have advocated a novel
> practical wavelet-based framework for integrating analog and
> digital modes of communication for
> transmitting images over noisy, time-varying channels. Our
> goal was to maximize the end-to-end delivered image quality
> subject to constraints on power and bandwidth. We considered a
> hierarchy of increasingly more sophisticated statistical
> wavelet-based image models. Our proposed joint source-channel
> coding algorithm, founded on a hybrid analog-digital framework, is
> validated both theoretically by its attractive proximity to the
> information-theoretic bounds on the underlying statistical image
> model used, as well as empirically by its excellent performance on
> real natural images. Our results indicate possibly significant
> performance gains, of the order of 3 dB in PSNR, compared to
> conventional state-of-the-art ``all digital" approaches to joint
> source-channel coding. Figure~\ref{system} gives a block diagram of
> the conventional and hybrid systems. Details can be found
> in [1].

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>2) Region-based video coding using mathematical morphology

>

> The motivation in this project was to use ideas from mathematical
> morphology for region-based video coding. Motion estimation and
> compensation has always been a critical problem
> for video coding. Traditional video coders use block-based motion
> compensation, which is simple and regular but causes blocky
> artifacts. New generation video coding standards such as MPEG-4
> calls for object-based approaches, which require understanding of
> the image
> semantics. In this project, we segmented the video frames into
> distinct regions, which intuitively correspond to moving physical
> objects. Then we estimated and coded the motion for
> each region. Regions could have arbitrary shape, and were found by
> "growing" from a "seed" using morphological operations.

>

> A striking feature of this coder is that the segmentation is
> based on decoded information, therefore region shapes or contours
> do not need to be coded. Regions can be merged, pruned, propagated,
> and modified from frame to frame. The

> coder performs among the best of current state-of-the-art
> region-based video coders, and outperforms MPEG-1 at around 1M bps
> (bits per second). Details of this work can be found in [2].
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>3) Multiresolutional motion estimation and video coding based on wavelets
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> Our objective in this project was to improve upon existing
> motion estimation schemes and tranform coding methods to come up
> with a video coder better than the state-of-the-art. We attempted
> to exploit the motion correspondences in a multiresolutional fashion.
> Specifically, we first code a coarse resolution version of the video
> frame, estimate a motion field from this coarse resolution, then
> apply it to predict the next finer resolution. Finally we coded the
> predicted difference of the finer resolution, then repeated the whole
> process for the next finer resolution, and so on. Wavelet transform
> provided the right tool for this framework, because of its inherent
> multiresolutional nature.
>
> In our work, it is found that motion relationship indeed bear
> considerable coherence across different resolution levels, but
> directly estimating them from wavelet coefficients is not feasible.
> A major problem is the aliasing noise resulted from downsampling
> operations in the transform. This problem is attacked by upsampling and
> filtering the coarser signals using a specially designed interpolation
> filter.
>
> The coder can operate in two modes: A purely backward mode in which
> no motion information is coded. A backward/forward hybrid mode in
> which the encoder judiciously
> chooses to send motion information for certain areas or at certain
> resolutions for each frame, and the decisions are optimized using
> zerotree coding and dynamic programming. The
> complete coder is efficient, scalable, and robust over large range
> of bitrates. It is compared against MPEG-1, at high bitrates
> (0.5-1.5 Mb/s), and with H.263 at low bitrates
> (24-128 kb/s). It achieves typically a coding gain of 1 dB over
> both standards. See [3] for details.
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